Proc. Indian natn. Sci. Acad. **B50** No 5 pp 535–538 (1984)

Trace Metal Status of Coconut Plants of a Polluted Area in Mysore

R K SOMASHEKAR
Department of Botany, Bangalore University, Bangalore 560056

(Received 24 October 1983; after revision 3 December 1984)

Differential accumulation of heavy metals among coconut trees growing in the polluted area was investigated. The accumulated concentration of metals such as Ni and Cu in coconut root and leaf extract was 46·84 and 10·89 mg^{-1}; 32·32 and 19·70 mg^{-1} respectively. Coconut water contained 12·6 mg^{-1} of Ni; 15·45 mg^{-1} of Cr and 14·13 mg^{-1} of Cu.

Key Words : Heavy metals Bioaccumulation, Electroplating waste water

Introduction

Flowering plants are known to accumulate heavy metals from dilute background concentrations of the aquatic environment. (Förstner & Wittman 1979). Bioaccumulation of heavy metals in plants such as *Elodea*, *Eichhornia*, *Citrus*, *Ipomea*, algae, mushrooms, lichens, bryophytes and other foodstuff plants has been demonstrated (Kiyosma et al. 1977, Rao et al 1977, Roger et al. 1977, Allen & Steinnes 1978, Suchecharoen 1978, Wolverton & McDonald 1978, Shacklette et al. 1980, Rai et al. 1981 and Ramaswamy and Somashekar 1982). Förstner and Wittman (1976) and Klien et al. (1977) reported that electroplating industries are one of the major sources of heavy metals pollution. The present work describes a two-year ecological study on heavy metal pollution around an automobile factory near Mysore, Karnataka, India. The study was undertaken to ascertain the extent of accumulation of heavy metals by coconut trees (*Cocus nucifera* L.) growing in the polluted area.

Materials and Methods

The factory, operating for the last 25 years is situated at a distance of 2 km from the Mysore City and it mainly employs Cr and Ni for plating and other metallic salts are contaminants. It discharges about 60,000 litres of heavy metal rich waste water per day (from electroplating section only). The waste water runs in the form of a small stream for about 1 km and subsequently joins one of the nearby sewage canals. The coconut trees planted at a distance of about 0.2 km from the factory are irrigated with this waste water. Soil in this area is reddish brown and poor in organic matter.

Monthly collection of effluents was made for two years, *i.e.*, from Jan. 1979 to Dec. 1980, along with soil and plant samples (*viz.*, root, leaf and coconut water), from both polluted and unpolluted area. Ten trees growing in polluted area were considered. Coconut plants growing in the same area, but supplied with fesh water served as control.

Standard methods (APHA 1976) were used during the collection, preservation and analysis of the samples. Soil samples were collected from a depth of 5″. Usually, portion of young root, young leaf (from three years old tree) and nearly $2\frac{1}{2}$ months old tender coconut (from the ten years old tree) were collected for analysis. Before analysis the plant samples were thoroughly washed with dilute acid to remove adsorbed metals. For estimating the heavy metal content of soil and plant samples, 5 g of material was oven-dried (70°C) for 48 hr and fine powder was prepared. The samples were digested for 4 hrs using 4 ml of perchloric acid and 8 ml of nitric and sulphuric acid. For analysing heavy metal content of water, waste water and coconut water 100 ml of sample was taken and digested using 4 ml of hydrogen peroxide, nitric acid and sulphuric acid. A Perkin Elmer Model 403 atomic absoprtion spectrophotometer was used for the estimation of heavy metals such as Cu, Ni, Cr. Zn, Cd, Co and Pb, following the procedure described elsewhere (Van Loon 1980). Cyanides as CN was estimated by employing standard methods (APHA 1976). *p*H was estimated by using 'Systronics' digital *p*H meter.

Results and Discussion

The mean $\pm$ SD values of 24 observations on total trace metal content in water, waste water and soil samples, analysed for the period from Jan. 1979 to Dec. 1980 are given in table 1. Of the elements analysed copper, nickel and chromium were found in significant amounts in the effluents of the industry. The concentrations of these metals especially chromium, copper, nickel and lead were high in soil samples collected from the polluted area (table 1).

Comparative accumulation of trace metals in different parts of coconut trees growing in the polluted area are given in table 2. Highest concentration of heavy metals reported from coconut water is Co, 0.01; Cr, 0.15; Cu, 4.00; Pb, 0.015; Zn, 16.0 and

Table 1 *Trace metal and cyanide concentrations (Mean $\pm$ SD of 24 observations) of the soil samples (mg/kg) and effluents (mg^{-1}) in the polluted and unpolluted (control) areas.*

Factors	Mean $\pm$ SD values			
	Polluted area		Unpolluted area (control)	
	Soil	Effluents	Soil	Water Samples
*p*H	6·8±0·13	7·8±0·19	6·6±0·11	7·2±0·11
Nickel as Ni^{2+}	222·5±1·23	83·2±0·81	1·24±0·13	0·16±0·01
Chromium as Cr^{3+}	240.2±1·40	156·0±0.84	0·13±0·01	0·11±0·01
Copper as Cu^{2+}	110·7±0.83	44·6±0.36	1·87±0·10	0·13±0·01
Zinc as Zn^{2+}	35·1±0·18	15·4±0·13	10·3±0·12	0·34±0·03
Cadium as Cd^{2+}	16·0±0·16	3·4±0·01	10·1±0.14	0·12±0.01
Cobalt as Co^{3+}	22·5±0·20	0·8±0·03	0·97±0·11	0·07±0.01
Lead as Pb^{2+}	29·0±0·11	4·6±0.14	1·03±0·16	0·19±0.01
Cyanides as Cn	—	5900±3.84	—	—

Table 2 *Metal concentration in coconut plant : A comparative account in mg/l values are Mean±SD of 24 observations*

Sample description	Cu	Pb	Zn	Ni	Co	Cd	Cr
1. Coconut root extract	32·32±0·47	11·53±0·39	29·71±0·18	46·84±0·73	1·89±0·43	40·31±0·81	61·40±0·63
Control	7·10	2·10	9·68	1·14	0·13	2·32	1·69
2. Coconut leaf extract	19·7±0·96	81·18±0·87	29·55±0·93	10·89±0·61	1·32±0·52	14·58±0·43	23·91±0·28
Control	8·23	1·02	10·97	0·35	0·11	0·11	0·13
3. Coconut water	14·3±0·74	6·14±0·21	2·66±0·92	12·61±0·12	2·09±0·01	3·79±0·32	51·45±0·87
Control	4·64	0·21	1·92	0·12	0·01	Traces	Traces

Nil, 1.0 mg/l (Duke 1970), as against Co, 2.09; Cr, 15.45; Cu, 10.13; Pb, 6.14; Zn, 6.66; Ni, 12.61 and Cd, 3.79 mg/l observed in the present study. The values of heavy metals for control plants were considerably less and in comparison with the control, in all the cases the results remained statistically significant. The roots contained high concentration of Cu, Ni and Cr than the leaves. From table 2, Zn and Co content of root and leaf are not statistically significant; whereas Pb content of leaves is higher than that of roots. A similar differential accumulation of metals in roots, stem and leaves of different species of plants have been reported by Heydt (1977). Whether this differential accumulation is due to the tendency of different parts to accumulate different metabolites, needs further investigation.

Shacklette et al. (1980), opined that the available amounts of metals rather than only total amounts, determine the uptake of an element by a plant from the soil and the available amount changes with the chemical environment. Most probably *p*H is one of the factors and in the present study the *p*H values ranged from slightly acidic to slightly alkaline condition. Besides the physical-chemistry of metals, interactions with other metals and the factors influencing the physiology of organisms determine the level of heavy metal uptake (Whitton & Say 1975).

Gibbs (1973) observed that the presence of metals in solution form accounts for higher percentage of uptake. Organic matter has been considered as the other factor (Nakhsina & Feldman 1972). The metals such as Cu and Zn have been shown to interact with bottom deposits and suspended matter. The waste waters in the present study contained organic matter and they formed the bottom sediment along the effluent canal. Therefore the quantity of the metal absorbed by the plants varies with the availability of metal in ionic form. It is however, still not clear to what extent the levels and types of organic matter present in the water are likely to bring about significant increase in the level of metal absorption.

It is also argued that due to continuous exposure the organisms loose the mechanism for controlling the accumulation of metal and exhibit good growth (Whitton & Say 1975). However, in flowing water with occasional pulses of higher metal concentration, plants have been shown to grow normally through the mechanism of 'adaptation'. Most probably this factor is regulating the presence and growth of plants in the present area. As suggested by Antonovics et al. (1971) ultimately it may lead to the evolution of metal tolerant races.

The trace metal concentration in coconut water in the present study is higher than the limit prescribed by WHO (1971) for drinking water. Regular consumption of this coconut water containing higher concentration of metals may lead to an increased accumulation of the metals in the human system over a period of time thereby resulting in carcinogenic and mutagenic effects (Goyer & Mehlman 1970). Greater concentrations of metals in the soil and coconut water samples also suggest that the electroplating wastes should not be used for irrigating either plantation crops or vegetables.

References

Allen R O and Steinnes E 1978 Concentrations of potentially toxic metals and trace elements in wild mushrooms from Norway; *Chemosphere*; *Chemistry Physics* and *Biology as focussed on environmental problems*, 7 371–378

Antonovics J, Bradshaw A D and Turner R G 1971 Heavy metal tolerance in plants; *Adv. Ecol. Res.* 7 1–85

APHA, AWWA and WPCF 1976 *Standard Methods for the examination of Water, Waste water and Sewage*, 14 edn. (New York: APHA Inc.)

Duke J A 1970 Ethnobotanical observations in the Choco Indians; *Eco. Botany* **24** 344–366

Förstner V and Wittman G T W 1979 *Metal Pollution in the Aquatic Environment* (Berlin: Springer Verlag)

Gibbs R J 1973 Mechanisms of trace metal transport in rivers; *Science* (New York) **180** 71–73

Goyer R A and Mehlman M A 1970 (ed) Toxicology of trace elements; in *Advances in Modern Toxicology*, Vol. 2, (New York : John Wiley Sons)

Heydt G 1977 *Schwermetallogehalte van Wasser, Wasser pflanazen, Chironomidae und Mollusca der Elsenz* (Heidelberg : Dipl. Arbeit Univ.)

Kiyosma M T and Teruto Y Y 1977 Heavy metals concentration in Citrus plants and soil and correlation to air pollution at Saganosaki, Nagoya; *Gij. Sci.* 7 15–24

Klien L, Lang M, Nash N and Kirshchner S L 1977 Sources of metals in New York waste water; *J. Water Pollut. Control. Fed.* **46** 2653–2662

Nakhsina Ye P and Fel'd Man M V 1972 The effect of certain factors on the branding of Zinc and Copper by the bottom oozes in water bodies; *Hydrobiological J.* **4** 12–17

Rai L C, Gaur J P and Kumar H D 1981 Phycology and heavy metal pollution; *Biol. Rev.* **56** 99–151

Ramaswamy S N and Somashekar R K 1982 Ecological studies on Algae of Electroplating wastes; *Phykos.* **21** 83–90

Rao D N, Robitale C and LeBlanc F 1977 Influence of heavy metal pollution on lichens and bryophytes; *J. Hattori Bot. Lab.* **42** 213–239

Roger A M, McIntosh A W and Anderson V L 1977 Uptake of Cd and Pb by a rooted aquatic macrophyte (*Elodea canadensis*); *Ecology* **58** 1176

Shacklette H T, Erdman J A, Harms T F and Papp C S E 1980 Trace elements in plant foodstuffs; in *Toxicity of Heavy Metals in the Environment* ed. F W Oeheme (New York: Marcel Dekken Inc.)

Suchecharoen S 1978 Mercury accumulation in *Ipomea aquatica* near a caustic soda factory in Thailand; *Water air soil Pollut.* **10** 451–455

Van Loon J C 1980 *Analytical Atomic Absorption Spectroscopy* (New York: Academic Press)

WHO 1971 *International Standards for Drinking Water* (Third Edition, Geneva)

Whitton B A and Say P J 1975 Heavy metals; in *River Ecology* ed. B A Whitton (Oxford: Blackwell Sci. Publs.)

Wolverton B C and McDonald R C 1978 Bioaccumulation and detection of trace metal levels of cadmium in aquatic systems by *Eichhornia crassipes*; *Proc. Workshop in Environmental Health Perspectives* **27** 161–164